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R&D in Canadian
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1979



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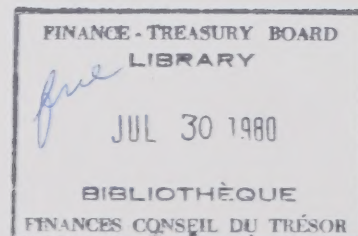


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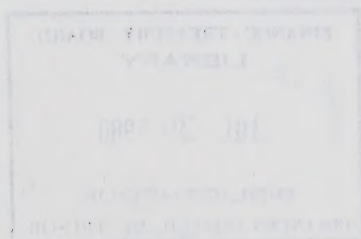



TABLE OF CONTENTS

	<u>PAGE</u>
1. Introduction	1
2. The Statistical Background	4
3. R&D and Foreign Control: Aggregate Results	8
4. R&D Performance by Industry	14
i) Some General Considerations	14
ii) Pulp and Paper and Primary Metals	18
iii) Electrical Products	20
iv) Machinery	22
v) Chemicals	24
vi) Aircraft and Parts	25
vii) An Evaluation of the Results	26
5. The Role of International Transfers of Technology	28
6. Conclusions	39
APPENDIX A: Some Notes on the Foreign Investment Data	43
APPENDIX B: Notes on the Export Data for U.S.-Controlled Firms	47

LIST OF TABLES

	<u>PAGE</u>
1. Measures of Research Intensity by Industry, 1975	6
2. Foreign Control in the Canadian Economy, 1975	7
3. Foreign Control of Sales and R&D by Research-Intensive Industry, 1975	13
4. R&D in Canadian and Foreign-Controlled Firms by Research-Intensive Industry, 1975	16
5. Relative Sales and R&D in Canadian and Foreign-Controlled Firms by Research- Intensive Industry, 1975	16
6. R&D and Number of Firms by Size of R&D Program, 1975	17
7. Pulp and Paper Companies, 1977	19
8. Relative R&D Performance in the Electrical Products Industry, 1975	22
9. Intramural R&D Expenditures and Technology-Related Payments to Non- Residents by Research-Intensive Industry, 1975	30
10. Relative "R&D" (Including R&D and Technology-Related Payments to Non- Residents) by Research-Intensive Industry, 1975	30
11. Relative Export Performance of Foreign- Controlled Firms by Research-Intensive Industry, 1970	33



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R&D IN CANADIAN AND FOREIGN-CONTROLLED MANUFACTURING FIRMS

1. Introduction

The lower level of industrial R&D in Canada, relative to other OECD nations, has been the subject of much attention. The reasons for this apparent gap are numerous and complex. Previous papers prepared in MOSST, examining the relative performance of Canada's research-intensive industries, indicated that foreign-controlled firms perform significantly less R&D relative to sales than those which are Canadian-controlled, and that Canada has consistently recorded a trade deficit in technology-intensive commodities(1).

This paper extends that earlier work and examines in more detail the nature of the relationship between foreign control and R&D. It shows that

(1) MOSST, Background Paper No. 4, Performance of Canadian Manufacturing Industries by level of Research Intensity, and Background Paper No. 5, Canadian Trade in Technology-Intensive Manufactures, 1964-76. (July, 1978).

foreign-controlled firms, although being less research-intensive, are generally more technology-intensive than their Canadian-controlled counterparts because of their access to imported technology, and this is reflected in their higher profits and productivity.

At the same time, the export performance of Canadian-controlled firms is markedly better. Because of the small size of Canadian markets, research-intensive firms generally are strongly oriented toward export markets. This leads to the conclusion that the R&D performed by foreign subsidiaries is not only quantitatively less but also qualitatively different, being principally directed toward adapting imported technology to the domestic market, as opposed to more innovative work aimed at export. Given the predominance of foreign-controlled firms in the technology-intensive industries, this helps to explain why Canada has a persistent trade deficit in this area.

The poorer export record of foreign-controlled firms may seem paradoxical in light of their better profit and productivity performance. This is attributed to their more fragmented production structure and

subsequent lack of specialization which, in turn, reflects the impact on their more diversified production activities of the historically high levels of tariffs imposed on manufactured goods both in Canada and abroad. Canadian-controlled firms are generally smaller and have a more limited range of products. Accordingly, they are more specialized and the Canadian market accounts for a relatively smaller proportion of their total sales.

The results serve to emphasize that the payoff from both imported technology and domestic R&D, and especially the R&D performed in foreign-controlled firms, has not been maximized in Canada due to the lack of sufficient specialization. The relevant question, therefore, from a policy point of view, is how the forces at work in Canadian manufacturing, which have tended to limit the potential performance of foreign-controlled firms, can be changed to ensure that Canada takes full advantage of its innovative capacity.

2. The Statistical Background

Research and development is usually measured on the basis of expenditures and employment. These data are subject to a number of qualifications, the most important of which is that they measure input, not output, and say nothing about the efficiency with which R&D programs are conducted. Employment indicators are also just partial estimates of input. Thus, comparisons among firms and industries of R&D personnel to total employment may be more a reflection of variations in capital intensity than research effort. Expenditure indicators, although covering all inputs, fail to distinguish between price and quantity effects. Thus, if a firm faces lower prices for its R&D inputs, its R&D expenditures will be correspondingly lower although it may be maintaining a level of activity at least as great as in another industry.

Research and development also covers a wide range of activities, from basic and applied scientific investigation to engineering and designing functions. Thus, companies with comparable R&D expenditures and employment may be involved in fundamentally different types of work and, even where R&D projects are similar, their

success will still be critically dependent on other decisions of the firm, affecting its investment, marketing and manufacturing plans. Some of these qualifications will be discussed in more detail at a number of points in the paper where they are judged to affect the interpretation of the statistical results.

In current dollars, R&D expenditures quadrupled between 1963 and 1977 although when expressed as a proportion of GNP they have declined to 0.9 per cent in 1977 after reaching a peak of 1.3 per cent in 1968. The business sector's share of total R&D has increased slightly over time and currently accounts for about 45 per cent of total expenditures. More than 80 per cent of this total is performed by manufacturing and is concentrated in seven key industries: electrical products, petroleum, machinery, chemicals, transportation equipment, primary metals and pulp and paper. These industries, although accounting for less than one-half of value added in manufacturing, make up 90 per cent of all R&D. In addition, when their R&D expenditures are related to overall measures of industry size (sales, value added), they are also observed to be the most research-intensive. (Table 1)

TABLE 1
Measures of Research Intensity
by Industry, 1975¹

	Percentage of Current Intramural R&D Expenditures ²	Percentage of Total Value Added ³	R&D/Value Added
<u>High Research-Intensity</u>			
Electrical Products (16)	29.9	7.9	5.1
Petroleum & Coal Products (18)	7.7	2.2	4.6
Machinery (14)	12.4	5.3	3.2
Chemical Products (19)	12.5	6.9	2.5
<u>Medium Research-Intensity</u>			
Primary Metals (12)	10.3	7.6	1.8
Transportation Equipment (15)	12.0	10.9	1.5
Paper & Allied ⁴ (10)	4.8	9.0	0.7
<u>Low Research-Intensity</u>			
Rubber & Plastics (3)	1.0	2.7	0.5
Textiles (5)	1.0	2.8	0.5
Food, Beverages, Tobacco (1,2)	4.2	14.8	0.4
Non-Metallic Minerals (17)	0.9	3.9	0.3
Metal Fabricating (13)	1.8	8.5	0.3
Wood (8)	0.4	4.4	0.1
Furniture (9)	0.1	1.9	0.1
Other Manufacturing (4,6,7,11,20)	1.0	11.2	0.1
Total Manufacturing	100.0	100.0	1.3

1 The numbers in brackets refer to SIC codes. See, Statistics Canada, Standard Industrial Classification Manual, Cat. 12-501, Occasional, 1970

2 All data on R&D are based on Statistics Canada sources, see especially, Annual Review of Science Statistics, Catalogue 13-212, 1977, Annual

3 Value added data come from Statistics Canada, Manufacturing Industries of Canada: National and Provincial Areas, 1975, Cat. 13-203, Annual

4 The research intensity of paper & allied industries has traditionally been between one and two per cent of value added. The low level for 1975 reflects the combined effect of an exceptionally large number of special circumstances (strikes, extreme sales fluctuations, rapid production cost increases etc.)

The data on foreign control (Table 2) show a pattern of concentration remarkably similar to that for R&D. Manufacturing and mining account for almost 70 per cent of all foreign control and are the only sectors in which foreign-controlled firms are predominant, with levels of control reaching 57.7 and 67.2 per cent, respectively, in 1975. Foreign control is even higher in the research-intensive group with foreign-controlled firms accounting for over 70 per cent of these industries' sales in 1975.

TABLE 2

Foreign Control in the
Canadian Economy, 1975^{1,2}

	Foreign Control of Sales (%)	Distribution of Foreign Control (%)	Distribution of Sales (%)
Agriculture, Forestry, Fishing	7.5	0.2	1.0
Mining	67.2	8.9	4.8
Manufacturing	57.7	59.5	37.7
High & Medium Research	71.9	40.9	20.8
Low & No Research	40.2	18.6	16.9
Construction	14.1	2.8	7.3
Trans., Communications, Utilities	10.6	2.3	8.1
Wholesale Trade	28.0	15.0	19.5
Retail Trade	18.4	8.2	16.2
Other Services	21.1	3.1	5.4
Total Economy	36.6	100.0	100.0

1 Unincorporated business, financial institutions and non-commercial activities are not accounted for in these estimates. This tends to overstate the degree of foreign control and to understate the percentage share of sales for agriculture, fishing and forestry, construction, trade and other services.

2 Data on foreign control come from Statistics Canada, Corporation and Labour Unions Returns Act, Part I - Corporations, 1975, Cat. 61-210, Annual.

3. R&D and Foreign Control: Aggregate Results

The predominance of foreign-controlled firms in the research-intensive industries does not mean that they are necessarily more research-intensive but only that they tend to be concentrated in those industries where most R&D is performed. In 1975, for example, foreign-controlled firms, although accounting for over 70 per cent of sales in the research-intensive industries, were responsible for only one-half of the \$460 million spent on current intramural R&D. At first blush, this would tend to confirm that foreign-controlled firms perform significantly less R&D, relative to sales, than Canadian-controlled ones. Although literally correct, such a generalization would be somewhat misleading. In fact, much of the divergence is the result of imbalance in the pattern of ownership within the research-intensive industries, especially in the petroleum and transportation equipment industries, and cannot be attributed to inherent differences in the research intensity of Canadian and foreign-controlled firms.

The petroleum industry is one of the most research-intensive in the economy when measured by R&D

expenditures per unit of value added. However, when sales are used, research intensity falls from 4.6 per cent to 0.7 per cent, as compared to 2.4 per cent to 0.9 per cent for the rest of the research-intensive industries. The sharper decline in the petroleum industry simply reflects the very high price of oil and tends to produce a distorted picture of the industry's true research effort.

The relatively lower R&D-to-sales ratio in the petroleum industry would not be so significant if control were relatively evenly distributed among Canadian and foreign sources. However, in 1975, over 95 per cent of sales were by foreign-controlled firms, accounting for between 10 and 15 per cent of all foreign control in the research-intensive industries. In contrast, less than one-half of one per cent of all Canadian control in the research-intensive industries was attributable to the petroleum industry. Because of confidentiality restrictions, no data are available on the relative R&D expenditures of the two groups of firms. Nevertheless, it is unlikely, given the tremendous size differential, whether the comparison would carry much significance. In any case, the petroleum industry should be excluded when comparing the aggregate research intensities of

Canadian and foreign-controlled firms because part of the observed divergence reflects differences in industry mix which is a different issue from the one under examination in this paper.

The classification of the transportation equipment industry as research intensive is attributable to just one of its subcomponents, namely, the aircraft and parts industry. In fact, by the criteria adopted earlier in the paper, the rest of the industry would only qualify as a low research-intensive industry. In 1975, the R&D expenditures of the other transportation equipment industries totalled less than \$15 million, representing less than one-half of one per cent of value added (0.38 per cent) and less than one-tenth of one per cent of sales (0.0095 per cent).*

* This does not imply that there are no research-intensive firms. For example, on the basis of published sources, it has been estimated that the R&D-to-sales ratio for Bombardier-MLW Ltd. was about 1.8 per cent in 1977, accounting for over one-half of all Canadian-controlled R&D in other transportation.

Foreign-controlled firms dominate the principal industries in other transportation equipment. They accounted for more than 90 per cent of total sales in 1975 and represented over 25 per cent of all foreign control in the research-intensive industries. Like the petroleum industry, the other transportation equipment industries are the source of much of the observed divergence in the aggregate research intensities of Canadian and foreign-controlled firms.

The R&D activities of foreign-controlled firms, especially in the motor vehicle and parts industries, have recently been the subject of much increased attention. Again, however, the issue in this case has not been the divergence in the research intensities of Canadian and foreign-controlled firms but, rather, the research performance of the foreign subsidiaries relative to their parent corporations. This involves a set of considerations not directly related to this paper and, for this reason, the other transportation equipment industries will also be excluded from the subsequent analysis.

Even with the removal of the petroleum and other transportation equipment industries, foreign-controlled

firms continue to dominate the most research-intensive industries. As shown in Table 3, Canadian-controlled companies are generally more prevalent in the resource-related and relatively less research-intensive industries. Despite this pattern, foreign-controlled firms, although accounting for 55 per cent of sales, still make up just 48 per cent of the \$405 million spent on R&D. In the most research-intensive industries, they account for over 70 per cent of sales but only 55 per cent of R&D. Inherent differences in the research intensity of different industries, coupled with differences in the industry mix of Canadian and foreign-controlled firms, make it difficult to say anything further about these aggregate figures. The subsequent discussion, therefore, concentrates on an examination of each individual industry.

TABLE 3
 Foreign Control of Sales and R&D
by Research-Intensive Industry, 1975

	Foreign Control of Industry Sales (%)	Foreign Control of R&D (%)	R&D/Value Added (Total Industry) (%)
High Research Intensity	72.7	54.4	4.4
Aircraft and parts	82.7	58.1	11.0
Electrical products	65.6	40.9	5.1
Machinery	67.5	68.6	3.2
Chemical products	82.9	68.3	2.5
Medium Research Intensity	32.4	19.9	1.2
Primary metals	17.1	14.0	1.8
Paper and allied	43.6	32.8	0.7
Total	55.3	47.7	2.9

4. R&D Performance by Industry

i) Some General Considerations

Table 4 shows the R&D expenditures of Canadian and foreign-controlled firms in the research-intensive industries during 1975. Table 5 relates these figures to firms' respective level of sales. Where possible, industries have been further disaggregated to produce more precise results. Again, the same pattern is observed to emerge. With one minor exception, the R&D expenditures of Canadian-controlled firms are higher relative to sales than their foreign-controlled counterparts in every industry grouping.

It would still be premature, on the basis of Table 5, to attribute the differences in research intensity strictly to ownership. Just as there are inherent inter-industry differences in research intensity, similarly, factors may be identified at the sub-industry level to explain differences in firms research intensity for reasons unrelated to ownership. In particular, R&D expenditures in the same industry increase with firm size and, within a fairly broad range, research intensity is greater in larger firms.

Furthermore, it is apparent, even within the most research-intensive industries, that R&D expenditures are not distributed equally across all product lines, and that much of the output of these industries comprise standard technology items. For example, it has been estimated for the U.S. that 79 per cent of machinery, 38 per cent of electrical products and 31 per cent of chemicals are made up of product lines with research intensities below the average for total manufacturing.(2) Until these factors are taken into account, few conclusions can be drawn about relative R&D intensities because what will be attributed to ownership may simply be the result of structural differences within each industry which are not apparent at the aggregate level.

(2) U.S. Department of Commerce, Alternative Measurements of Technology-Intensive Trade, Staff Economic Report, Bureau of International Economic Policy and Research, 1976.

TABLE 4

R&D in Canadian and Foreign-Controlled Firms
by Research-Intensive Industry, 1975
(\$Millions)

	Canadian- Controlled	Foreign- Controlled	Total
Pulp and Paper	16.8	8.2	25.0
Primary Metals	46.2	7.5	53.7
Ferrous	11.1	1.4	12.5
Non-Ferrous	35.1	6.1	41.2
Electrical Products	88.0	60.7	148.7
Machinery	20.3	44.4	64.7
Business Machines	2.8	21.9	24.7
Other Machinery	17.5	22.5	40.0
Chemicals	20.7	44.7	65.4
Pharmaceuticals	7.7	18.6	26.3
Other Chemicals	13.0	26.1	39.1
Aircraft and Parts	20.3	28.1	48.4
Total	212.3	193.6	405.9

TABLE 5

Relative Sales and R&D in
Canadian and Foreign-Controlled Firms
by Research-Intensive Industry, 1975

	Canadian-Controlled		Foreign-Controlled	
	% Sales	% R&D	% Sales	% R&D
Pulp and Paper	56.4	67.2	43.6	32.8
Primary Metals	82.9	86.0	17.1	14.0
Ferrous	87.0	88.8	13.0	11.2
Non-Ferrous	78.6	85.2	21.4	14.8
Electrical Products	34.4	59.2	65.6	40.8
Machinery	32.5	31.4	67.5	68.6
Business Machines	14.8	11.3	85.2	88.7
Other Machinery	35.0	43.8	65.0	56.2
Chemicals	17.1	31.7	82.9	68.3
Pharmaceuticals	13.2	29.3	86.8	70.7
Other Chemicals	18.3	33.2	81.7	66.8
Aircraft and Parts	17.3	41.9	82.7	58.1

The tendency for R&D to be concentrated in large firms, coupled with the relatively small size of the Canadian economy, further complicates the interpretation of the estimates on research intensity. These figures are simply statistical averages and differences within an industry could be attributable to the behaviour of even one individual firm and would not necessarily reflect an industry-wide phenomenon. For example, Table 6 shows that over 70 per cent of R&D expenditures in the business sector were accounted for by just 100 companies.

TABLE 6
R&D and Number of Firms
by Size of R&D Program, 1975

	<u>Size of R&D Program (\$millions)</u>				Total
	Less than 0.1	0.1-0.4	0.4-1.0	1.0+	
Total R&D (\$millions)	18.6	77.1	68.2	459.0	622.9
%	3.0	12.4	10.9	73.7	100.0
Total Number of Firms	284	382	112	100	878
%	32.3	43.5	12.8	11.4	100.0
Average R&D Program (\$millions)	.064	.202	.609	4.590	.709

Data, allowing direct comparisons of firms R&D activities, are not available on a consistent basis in Canada. However, after accounting for differences in

firm size and product mix, some attempt is made in the subsequent discussion to develop such estimates. In this manner, it will be possible to provide some indication of the extent to which differences in research intensity are industry-wide as opposed to firm-specific phenomena. Such a distinction, although not affecting the overall statistical results, could be important since the two explanations could have very different implications for future policy analysis and development.

ii) Pulp and Paper and Primary Metals

Firm size more than ownership may be the reason for the better research performance of Canadian-controlled firms in the pulp and paper and primary metals industries. Unlike other research-intensive industries, Canadian-controlled firms are generally larger and more well established than their foreign-controlled counterparts in these industries. For example, eight firms account for over one-half of total sales in pulp and paper, of which five, including the three largest, are Canadian-controlled (MacMillan Bloedel, Domtar and

Abitibi-Price). At the same time, it could be argued, on the basis of partial results, that foreign-controlled firms within the leading eight firms are just as research-intensive as Canadian-controlled ones (see Table 7).

TABLE 7
Pulp and Paper Companies, 1977

	Total R&D ¹ (\$ Millions)	Total Sales ² (\$ Millions)	R&D/Sales	Major Shareholder ²
Canadian International Paper	3.7	780.0	0.47	International Paper (U.S.) 100%
Domtar	4.5	1009.5	0.45	Argus Corp (Canada) 17%
MacMillan Bloedel	6.6	1707.3	0.39	CP Investments (Canada) 13%

¹ Financial Post, "The New Technology: What's in it for Canada and You", June 10, 1978 p.35-42

² Canadian Business, "The Top 400", July, 1978 pp 60-101

Differences in firm size could be even more important in the ferrous metals industry (a sub-component of primary metals). There are no foreign-controlled firms among integrated steel producers in Canada and, in the industry as a whole, the largest firms are almost all Canadian-controlled. In particular, Canadian-controlled firms' large share of R&D is a reflection of Stelco which performs approximately one-half of all R&D in the industry.

The eight leading producers in the non-ferrous metal industry account for over 90 per cent of sales. Although there are some important foreign-controlled firms in this group (Sherritt-Gordon and Reynolds), they are relatively small when compared to their Canadian-controlled counterparts (Alcan, Inco, Noranda, Cominco, Hudson Bay Mining, and Falconbridge). Accordingly, the observed difference in their respective research intensities is not surprising, especially when it is noted that approximately two-thirds of industry R&D, and almost 80 per cent of Canadian-controlled R&D, is concentrated in two firms (Alcan and Inco).

iii) Electrical Products

Based on U.S. results, where the ownership element is not a relevant factor, it is apparent that research intensity varies widely within the electrical products industry. In particular, communication equipment manufacturers have shown significantly higher research intensities than manufacturers in the rest of the industry. In 1968, for example, their respective research intensities in the U.S., as measured by R&D to

sales, were 15.2 per cent and 2.5 per cent.

Foreign control of the electrical products industry in Canada is not evenly distributed but is heavily weighted toward those areas with relatively lower research intensities. For example, in 1972, less than one-half (48.3 per cent) of sales in communications equipment were foreign-controlled as compared to 68.5 per cent for all other electrical products. Because of these structural differences, little can be said initially about the observed divergence in the aggregate research intensities of Canadian and foreign-controlled firms. In fact, many of the major foreign-controlled firms in the industry have significant R&D programs. At the same time, the Canadian-controlled component of R&D is dominated by one firm, Northern Telecom,* which is in the communications equipment industry.

A lack of sufficiently detailed data makes it difficult to adjust for intra-industry differences in product mix. However, on the basis of published sources,

*The major part of Northern Telecom's R&D is conducted through its 70 per cent owned subsidiary, Bell-Northern Research Ltd.

it has at least been possible to develop estimates of industry R&D and sales excluding Northern Telecom. Based on these results (see Table 8), it is apparent that a large part of the difference in the research intensity of Canadian and foreign-controlled firms in the electrical products industry reflects the dominance of Northern Telecom and is not attributable to ownership.

TABLE 8
Relative R&D Performance in the
Electrical Products Industry, 1975*

	Sales (\$ millions)	R&D (\$ millions)	R&D/Sales
Other Canadian-Controlled Firms	1176.8	23.0	2.0
Foreign Controlled Firms	3798.2	60.7	1.6
Sub-Total	4975.0	83.7	1.7
Northern Telecom	815.0	65.0	8.0
Total Industry	5790.0	148.7	2.6

* The estimates for Northern Telecom have been derived from annual reports and the 10-K form submitted by the company to the U.S. Securities and Exchange Commission.

iv) Machinery

No significant difference exists in the research intensity of the Canadian and foreign-controlled compo-

nents of the business machinery industry (a subcomponent of machinery). Comparisons, in any case, would probably not be very meaningful since this statistical grouping is dominated by the very large, multinational computer companies.

The other machinery industry is made up of two principal groups: agricultural implements and commercial refrigeration and air conditioning equipment; and, miscellaneous machinery and equipment. Production is very concentrated in the former group, with over 50 per cent of shipments accounted for by four companies and over 70 per cent by eight companies. In the latter group, there are many small firms and even the fifty largest make up approximately only one-half of sales. Product lines also vary widely, many of which are not research-intensive. In the U.S., for example, only the production of diesel and general purpose engines and turbines was observed to have a ratio of R&D to sales greater than the average for total manufacturing. Without much more detailed data, therefore, few conclusions can be drawn about differences in the research intensity of Canadian and foreign-controlled firms operating in the industry.

v) Chemicals

The pharmaceutical industry, although making up little more than 10 per cent of sales in the chemical industry, is responsible for over 40 per cent of R&D. However, overwhelming differences in firm size cause particular problems in evaluating the research intensity of firms in this industry. For example, in 1972, the eight leading firms in the industry accounted for over 40 per cent of sales, none of which were Canadian-controlled. These firms had average sales of \$24.5 million as compared to \$7.9 million for all foreign-controlled firms. In contrast, average sales of Canadian-controlled firms were less than one million dollars. Although the larger firms in an industry will normally spend relatively more on R&D, increases in R&D, beyond certain limits, will be less than proportionate to increases in sales. It could be argued, therefore, given the lack of any Canadian-controlled firms among the major producers, as well as the tremendous size differentials (over thirty-fold between the average for the eight leading companies and that for all Canadian-controlled companies), that much of the difference in research intensity is attributable to firm size and not ownership.

Foreign control is as concentrated in the other chemical industries as in pharmaceuticals. In this case, however, it is unlikely that all of the divergence in research intensity could be attributed to differences in firm size. For example, it is known that a significant proportion of industry output (soaps and detergents, perfumes and cosmetics, paints and varnishes, industrial organic chemicals, etc.) is not very technology-intensive. The extent to which such variations reflect differences in product lines is difficult to determine. However, based on the electrical products and pharmaceutical cases, it is apparent that generalizations about averages may be misleading when industries are characterized by pervasive differences in firm size and product lines.

vi) Aircraft and Parts

Aircraft and parts is the only industry where the divergence in research-intensity can be clearly linked to the element of control. In fact, the size of the divergence is somewhat understated by the aggregate data since approximately 90 per cent of foreign-controlled R&D is attributable to one firm: Pratt and Whitney Aircraft of Canada Ltd. Among Cana-

dian-controlled firms, two of the principal performers of R&D are Canadair and De Havilland.

vii) An Evaluation of the Results

This analysis shows, contrary to earlier findings(3), that foreign-controlled firms in fact perform significantly less R&D relative to sales than do their Canadian-controlled counterparts. An important question is the extent to which this divergence is attributable to ownership rather than structural factors such as differences in product mix and firm size.

With the exception of pulp and paper, primary metals and aircraft, data constraints have effectively prevented the formulation of an unequivocal answer to this question. Structural factors in some industries

(3) See, for example, M.H. Watkins, Report of the Task Force on Foreign Ownership, Privy Council Office (Ottawa: 1968), A.L. Safarian, Foreign Ownership of Canadian Industry, (Toronto: 1966) and N.H. Lithwick, Canada's Science Policy and the Economy (Toronto: 1969)

(electrical products, business machinery, chemicals) appear to explain at least part of the divergence in R&D performance but even this somewhat circumscribed conclusion might be refuted with more detailed data. This is because R&D in the research-intensive industries is distributed in a very uneven manner, being heavily concentrated in relatively few firms. Without more detailed data, therefore, relating the R&D of these firms to their own as opposed to industry-wide sales, few definitive conclusions can be drawn using this methodology about the observed differences in the research performance of Canadian and foreign-controlled firms.

Of course, even with appropriate data, the analysis would still be incomplete because research-intensity is not synonymous with technology-intensity. The following section examines the relative position of Canadian and foreign-controlled firms with respect to this broader concept. This change in approach is useful because, as will become apparent, it also sheds more light on the factors contributing to the divergence in firms' research intensity.

5. The Role of International Transfers of Technology

Despite their lower R&D-to-sales ratio, it would be premature to conclude that foreign-controlled firms are less technology-intensive than their Canadian-controlled counterparts. R&D expenditures do not account for access to imported technology. The importance to subsidiaries of parent technology is reflected in their payments to non-residents for technology-related services. The notion of "technology-related payments" is imprecise. In addition, there is often no explicit charge associated with transfers of technology within multinational corporations. However, even when the analysis is limited to visible payments for patents, industrial designs, royalties, and scientific and research services (which excludes the more general categories of engineering services and professional and management services), it is apparent that estimates of R&D significantly understate the degree of technological sophistication embodied in foreign subsidiaries' outputs and production processes (Table 9).

Table 10 shows the extent to which the "R&D" performance of firms would alter if technology-related

payments to non-residents were included in the definition of R&D. Because of the statistical and definitional problems discussed above, not too much significance should be attached to the absolute numbers in Table 10. Nevertheless, the systematic manner in which the discrepancy between Canadian and foreign-controlled firms' R&D performance disappears, after adjusting for technology-related payments, is striking. This would tend to confirm that foreign subsidiaries are no less and, in fact, probably more technology-intensive than their Canadian-controlled counterparts, and that their access to foreign technology is the principal reason for their lower research intensity.

TABLE 9

Intramural R&D Expenditures and
Technology-Related Payments to Non-Residents
by Research-Intensive Industry, 1975¹

	Canadian-Controlled Firms			Foreign-Controlled Firms		
	R&D Expenditures (\$millions)	Tech.-Related Payments (\$millions)	Total	R&D Expenditures (\$millions)	Tech.-Related Payments (\$millions)	Total
Pulp and Paper	16.8	0.9	17.7	8.2	7.7	15.9
Primary Metals	46.2	0.1	46.3	7.5	4.5	12.0
Electrical Pds.	88.0	5.8	93.8	60.7	21.8	82.5
Machinery	20.3	1.5	21.8	44.4	21.1	65.5
Petroleum ²	2.0	0.1	2.1	37.9	17.2	55.1
Chemicals	20.7	0.5	21.2	44.7	41.5	86.2
Total	194.0	8.9	202.9	203.4	113.8	317.2

1 Data on payments to non-residents come from unpublished CALURA listings.

2 R&D expenditures for Canadian and foreign-controlled firms within the petroleum industry are confidential. The figure in the table is derived by assuming R&D is proportional to sales.

TABLE 10

Relative "R&D" (Including R&D and
Technology-Related Payments to Non-Residents)
by Research-Intensive Industry, 1975

	Canadian-Controlled Firms		Foreign-Controlled Firms	
	% Sales	% "R&D"	% Sales	% "R&D"
Pulp and Paper	56.4	52.7	43.6	47.3
Primary Metals	82.9	78.9	17.1	21.1
Electrical Products ¹	34.4	53.2	65.6	46.8
Machinery	32.5	25.0	67.5	75.0
Petroleum ²	4.0	4.0	96.0	96.0
Chemicals	17.1	19.7	82.9	80.3

1 If Northern Telecom were excluded, Canadian-controlled firms' share of sales and R&D would be roughly equivalent, about 20 per cent in each case.

2 Sales and "R&D" in the petroleum industry are equivalent by assumption.

The stronger economic performance of technology-intensive industries is now well documented. They have been shown to have higher aggregate rates of growth in output, employment and productivity, and lower rates of price increase.(4) In a similar fashion, it seems that foreign-controlled firms' access to imported technology gives them a competitive edge over their Canadian-controlled counterparts. Such comparisons "...are heavily influenced by the high proportion of very small Canadian-owned firms and plants. Even after adjusting for this, however, it would appear that ...labour productivity in foreign-owned firms is higher [and] ...foreign-owned corporations tend to earn higher profits...".(5)

But it should be underlined that foreign-controlled firms generally export relatively less than Canadian-controlled firms. Table 11 compares U.S.-controlled firms' share of sales and exports in

(4) MOSST Background Paper No. 4, Performance of Canadian Manufacturing Industries by Level of Research Intensity

(5) Economic Council of Canada, Fifteenth Annual Review, 1978, p.29

each of the research-intensive industries and, although data are unavailable, it seems reasonable to assume that a similar pattern would exist for other foreign-controlled firms as well. On this basis, it is seen that foreign-controlled firms in 1970 exported a smaller proportion of their output than those which were Canadian-controlled. In fact, in the most research-intensive industries (electrical products, machinery, chemicals) foreign-controlled firms accounted for almost 75 per cent of sales but only 35 per cent of exports.

TABLE 11

Relative Export Performance of Foreign-Controlled Firms
by Research-Intensive Industry, 1970

	U.S.-Controlled Firms		Other Foreign-Controlled Firms		All Foreign-Controlled Firms	
	% Sales ¹	% Exports ²	% Sales ¹	% Exports ³	% Total Sales	% Total Exports
Pulp and Paper	31.8	30.2	11.8	11.2	43.6	41.4
Primary Metals ⁴	12.4	3.9	10.0	3.1	22.4	7.0
Electrical Products	55.0	25.9	8.0	3.8	63.0	29.7
Machinery	70.6	33.6	6.4	3.0	77.0	36.6
Chemicals	59.2	29.3	23.3	11.5	82.5	40.8
Total	43.8	25.2	11.9	6.8	55.7	32.0

1 Statistics Canada, CALURA, 61-210, 1970, Table 3.31, pp 158-9

2 U.S. Tariff Commission, Implications of Multinational Firms for World Trade and Investment and for U.S. Trade and Labor (Washington: 1973), Tables A-25 and A-27, p. 378 and p. 380

3 This category includes all foreign-controlled firms not of U.S. origin. Export shares have been calculated for these firms on the assumption that their performance, relative to sales, would be the same as their U.S.-controlled counterparts.

4 Inco and Alcan were classified by CALURA as foreign-controlled until 1972. In order to be consistent with the U.S. source on exports, they have been treated in this table as Canadian-controlled and Primary Metals has been adjusted accordingly. The actual level of U.S. control in Primary Metals for 1970 was 31.3 per cent.

The poorer export performance of foreign-controlled firms may seem paradoxical in light of their better profit and productivity record. This situation is attributable to their more fragmented production structure which, in turn, reflects the impact on production of the historically high levels of tariffs imposed on manufactured goods both in Canada and abroad. In brief, foreign-controlled firms in Canada, in the face of significant trade barriers, have tended to concentrate on producing limited quantities of a wide range of products for the domestic market, while relying on technological imports from parent corporations for much of their competitive advantage.

It has recently been shown that Canadian-controlled firms generally have a more limited range of products and, therefore, tend to be less diversified than their foreign-controlled counterparts.(6) The findings in this paper indicate that Canadian-controlled firms are also concentrated in relatively less technology-intensive areas. By specializing in fewer product lines, however,

(6) Richard E. Caves, Diversification, Foreign Investment, and Scale in North American Manufacturing Industries, Economic Council of Canada (Ottawa: 1975)

Canadian-controlled firms in the technology-intensive industries have been able to support the R&D investments required to achieve an internal capacity for technological innovation. On the basis of their technological know-how, these Canadian-controlled firms would appear to be competitive both domestically and abroad in their chosen product fields. As a result, the Canadian market accounts for a relatively smaller proportion of their overall sales, compared to foreign-controlled firms.

There has been a tendency on the part of some observers to attribute the more fragmented production structure of foreign-controlled firms and their subsequent lack of exports and R&D to ownership per se instead of more fundamental causal factors. It is important to note in this context that similar variations in firm size and product diversification occur among firms even in countries where foreign investment is insignificant. In Canada, unfortunately, the combination of a small domestic market and significant domestic and foreign trade barriers, has provided diversified producers with limited opportunities for greater specialization. It is unlikely, therefore, that the behaviour of these more diversified firms would be very different

even if they were Canadian-controlled and the necessary technology had been acquired through other channels such as licensing agreements and joint ventures.

Japan is often cited as the case where an indigenous innovative capacity has been developed by retaining domestic control of industry while relying on licensing arrangements with foreign firms for technology. However, this overlooks the fact that the national market in Japan was sufficiently large to allow domestic producers, despite the existence of trade barriers, to achieve the minimum critical size required for meaningful R&D programs. A strong case can be made that the licensing option would have left Canada relatively worse off, given its small internal market. Licensing agreements generally preclude exports to a much greater degree than parent/subsidiary relationships, and provide no access to other types of foreign expertise in areas such as marketing, administration, production control and personnel training.

The differences in the export performance and structural make-up of Canadian and foreign-controlled firms raises further questions about the nature of foreign subsidiaries' R&D activities. As mentioned ear-

lier, R&D covers a wide range of activities, and firms with comparable expenditures may be involved in fundamentally different types of work. For example, considerable emphasis has been placed in previous work on the tendency of subsidiaries to use the basic designs and processes of their parents, while concentrating their own R&D efforts on adapting the basic technology to the special requirements of the small Canadian market. In fact, the relationship between subsidiaries and parent corporations can vary widely, from relatively complete autonomy, to that of largely dependent branch plants with limited decision-making and policy-making authority. Similarly, in the conduct of R&D, examples can be found of firms doing relatively independent research projects. Despite extensive work, therefore, no clear impression has emerged on the degree to which R&D expenditures of foreign subsidiaries reflect adaptation functions, as opposed to truly innovative activities, and there is even less agreement on what would constitute the optimal mix.

The findings in this paper confirm that subsidiaries draw heavily on the technology of their parents. Of course, access to imported technology does not necessarily mean that foreign-controlled firms' R&D ex-

penditures are qualitatively different from those which are Canadian-controlled. Nevertheless, the small size of most Canadian markets, relative to the number of products and production runs, has generally been viewed as insufficient to support extensive R&D programs.(7) This has led to the observation that firms with large R&D expenditures, although servicing the domestic market, must also strongly orient themselves toward export markets. On the basis of their export performance, therefore, there is little doubt that R&D in most subsidiaries is not only quantitatively less, but also qualitatively different.

In summary, the lack of specialization by foreign subsidiaries has tended to reduce their level of R&D expenditures because domestic sales have generally been insufficient to support the R&D required to develop new products and production techniques. It has also affected the qualitative make-up of the remaining R&D effort, however, directing it toward adaptive functions for the domestic market, as opposed to more innovative work aimed at exports.

(7) H.E. English, "Industrial Organization and Technical Progress", pp 131-2, in T.N. Brewis ed., Growth and the Canadian Economy (Toronto: 1968)

6. Conclusions

The policy issue implicit in this discussion is usually defined in terms of a question of balance between a country's reliance on domestically developed technology in contrast to that obtained from foreign sources. No country is technologically independent and, because of Canada's relatively small size, imported technology will continue to account for a significant proportion of its technological base. However, this paper shows that R&D in foreign-controlled firms is not only quantitatively less, but also qualitatively different, being primarily directed toward adapting foreign technology to domestic needs as opposed to exporting. This implies that the net gains from both imported technology and domestic R&D, especially the R&D performed by foreign-controlled firms, have not been maximized due to insufficient opportunities for greater specialization.

The need for greater rationalization in Canadian manufacturing has long been recognized. The evaluation of this question, however, has been discussed almost exclusively in terms of the free trade issue. The proponents of free trade, although clearly showing the ef-

efficiency losses inherent in limited scale and specialization, have tended to focus on the overall gains in the long-run of economy-wide tariff cuts. The problem with this approach is that it tends to ignore the path of adjustment to this better position, specifically, in terms of the impact on those individuals and industries who, in the short-run at least, would be worse off as a result of free trade.

The somewhat narrow perspective of the free trade literature is unfortunate since the most significant gains from increased specialization would occur within industries, especially on the part of foreign-controlled firms in the technology-intensive sector. This is the area where tariffs have had their most detrimental effect, and where the potential for export growth is greatest, given current trends in international trade. The achievement of greater specialization in the technology-intensive industries would require some restructuring in the current pattern of production but, fortunately, these adjustments could be largely internalized within existing firms. What is more important, however, is that the benefits of increased specialization would be clearly visible and widespread, in the form of overall increases in employ-

ment and production.

Because the decision by foreign firms to locate in Canada has commonly been attributed to the influence of tariffs, it has often been asserted that trade liberalization would result in their departure, with Canadian operations reverting to simply a distribution function for imports. However, this view fails to account for the significant changes which have occurred in the Canadian economy over the last twenty-five years. A well-educated and highly trained labour force, a sophisticated service economy, especially in financial and capital markets and in the supporting infrastructure of transportation and communications, and a relative abundance of increasingly scarce energy sources, especially in hydro-electricity and natural gas, combine to give Canada a comparative advantage which did not exist many years ago. Indeed, many foreign-controlled firms, as a result of tariff reductions in the 1960s, have already started to rationalize at least parts of their operations, and are becoming more research-intensive and export-oriented.

The further reduction of both domestic and foreign tariffs, as a result of the most recent GATT negotia-

tions, should provide additional incentive and opportunities for greater rationalization in the technology-intensive sector. In this manner, more efficient use could be made of highly qualified manpower, as resources now engaged in adapting imported technology would be released for more innovative work in those fields where firms chose to specialize. Access could also be maintained to foreign technology but it would act to complement and not distort or substitute for domestic R&D. In addition, the growth in new exports of technology-intensive commodities would reduce the current account deficit in end products, and the overall increase in national productivity would act to strengthen even further Canada's international competitive position.

In brief, although Canada has benefitted enormously as a consumer of technology-intensive products, it has not maximized to its fullest potential the payoff from their production.

Appendix ASome Notes on the Foreign Investment Data

The estimates of foreign direct investment used in this report are based on the information prepared by Statistics Canada(1) under the authority of the Corporations and Labour Unions Returns Act (CALURA). A number of points should be noted at this stage about the data. First, the terms foreign and Canadian are used in this report for reasons of pedagogical ease. In fact, CALURA data measure non-resident, not foreign equity holdings. To the extent Canadians outside the country or foreigners residing in Canada hold shares in Canadian companies, estimates of foreign and non-resident investment would not necessarily be the same.

Second, a distinction can be drawn between foreign ownership and control. Estimates of ownership measure all equity owned by foreigners while estimates of control take account of the total equity of companies in which at least 50 per cent of the voting stock is in

(1) Statistics Canada, CALURA, Part 1, Catalogue No. 61-210, Annual.

foreign hands. Thus, to the extent foreigners invest in Canadian-controlled companies, foreign ownership will be greater than control. Conversely, to the extent Canadians invest in companies which they do not control, estimates of foreign control will be greater than ownership. Since the examination of the R&D activities of a firm is ultimately concerned with one aspect of decision-making within the firm, attention is focused in this report on the concept of control. Estimates of foreign ownership and control in manufacturing have been very close over time, with control being slightly higher than ownership.

Third, where shareholdings are sufficiently dispersed, control of a company can be achieved through ownership of significantly less than 50 per cent of all shares. However, the incidence of such cases is very limited. For example, in manufacturing, less than 15 per cent of all foreign holdings are in companies where foreign ownership falls between 5 and 50 per cent. In addition, only 2 per cent of all foreign holdings fall into the 25 to 50 per cent range. Although these figures vary somewhat more at the detailed industry level, even if one assumed that a substantial proportion involved cases of minority control, there would be only a

marginal effect on the level and industrial distribution of foreign control and little or no impact on historical trends.

Fourth, the companies reporting to CALURA are limited to those with revenues in excess of \$500,000 or assets greater than \$250,000. These companies account for over 95 per cent of all manufacturing activity, as measured by sales or assets, a relationship which holds even at a more detailed industry level. It is apparent, therefore, in measuring foreign control, that the treatment of the smaller firms excluded from CALURA will have little effect on the overall results. Most of them in any case would appear, on the basis of partial evidence (2), to be Canadian-controlled. For these reasons, their sales are added in this paper to the Canadian component when calculating the degree of foreign control in each industry.

Fifth, once control of a company is determined, based on the ownership of its equity, estimates of control are developed by Statistics Canada using assets, equity, sales and profits. All these measures produce

(2) Ibid., 1975, p.21

roughly comparable results and the choice of indicator will depend largely on the objectives of the particular analysis. Since this paper compares the relative research performance of Canadian and foreign-controlled firms, using R&D to sales, control is measured by sales.

Sixth, estimates of foreign control are available from published CALURA data for only the major industry groupings within manufacturing. More detailed estimates of foreign control are available from other Statistics Canada sources (3) but for no later than 1972. Although foreign control has been relatively stable over time, some adjustments are made to these estimates when they are used in conjunction with data from other years.

(3) Statistics Canada, Structural Aspects of Domestic and Foreign Control in the Manufacturing, Mining, and Forestry Industries, 1970-1972, Catalogue 31-523, Occasional.

Appendix BNotes on the Export Data for U.S.-Controlled Firms

The estimates of U.S.-controlled firms' share of exports used in this report are based on data contained in the U.S. Tariff Commission Study, "Implications of Multinational Firms for World Trade and Investment and for U.S. Trade and Labour". The study was initiated in 1971 by the U.S. Senate Committee on Finance, as part of its International Trade subcommittee's more general investigation of U.S. policies toward international trade.

A major data source for the U.S. study was the Bureau of Economic Analysis (BEA) quadrennial survey of U.S. multinational corporations (MNC). Surveys were conducted in 1966 and 1970, the former being a complete census and, the latter, a sample of the 300 largest parent corporations. The 1970 sample survey covered over 70 per cent of the 1966 universe, so that it was possible for the Commission to develop, using the standard statistical techniques, estimates of the total universe for 1970.

The outstanding feature of the BEA survey was the

amount of disaggregation achieved in presenting the results. Data were compiled at a very detailed level, covering 58 separate industries, including 38 in manufacturing, and for 18 different countries.

Data on exports by commodity for each of these 18 countries were gathered by the Commission from the standard U.N. and O.E.C.D. sources. It is important to note, however, that BEA data classified industry, not commodity, exports. That is, all exports of a given MNC were classified to the firm's major industrial activity. Because many MNC's are conglomerates, active in numerous industries, this creates some inconsistency between the total export estimates (commodity-based data) and the MNC export estimates (industry-based data).

No adjustment could be made to correct for the above problem. Nevertheless, given the particular industries/commodities which are being examined, and the level of aggregation at which they are being matched, the differences should not be so severe as to affect the interpretation of the results. In any case, the effect of such a bias would be to overstate U.S.-controlled firms' share of exports since, as stat-

ed in the U.S. study, "the net result is that MNC-generated exports as listed for an industrial classification may be excessive when compared with that industry's exports based on customs [commodity] classifications" (p.269).

The following table presents the data contained in the Tariff Commission study from which the "export share" estimates, presented in Table 11 of this paper were developed.

Relative Export Performance of U.S.-Controlled
Firms by Research-Intensive Industry, 1970
(\$U.S. millions)

	Total Exports ¹ (1) \$	U.S.-Controlled Firms		
		Total Exports ² (2) \$	Export Share (2÷1) %	Sales ³ Share %
Paper & Allied	1980	598	30.2	31.8
Primary Metals	1058	41	3.9	12.4 ⁴
Machinery	1218	409	33.6	70.6
Electrical Pds.	533	138	25.9	55.0
Chemicals	553	162	29.3	59.2
Total	5342	1348	25.2	43.8

1. U.S. Tariff Commission, *op.cit.*, Table A-25 p.378

2. *Ibid.*, Table A-27, p.380

3. Statistics Canada, *CALURA*, 61-210, 1970, Table 3.31, p.158-9

4. See footnote 4 in Table 11

